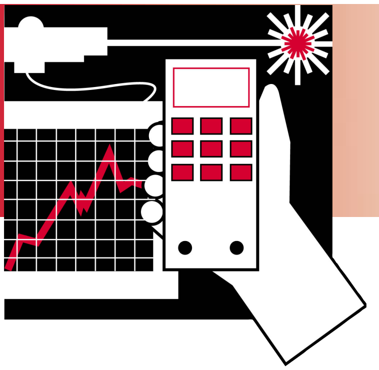
SENSORS & CONTROLS

Project Fact Sheet



Diode Laser Sensor for Combustion Control

Benefits

- This sensor system will allow *in situ*, simultaneous determinations of the concentrations of several furnace gases along with measurement of the gas temperature in less than one second.
- Nonintrusive measurement is advantageous for processes with high particle densities because it minimizes the maintenance issues associated with conventional, extractive sampling. In conjunction with no calibration requirements, this aspect allows for autonomous sensor operation.
- The sensor versatility provides for cross-cutting industrial applications in harsh combustion environments such as those associated with glass melting, steel, aluminum, and chemical operations.
- The coupling of the sensor with process control will lead to improved energy efficiency and pollutant reduction.

Applications

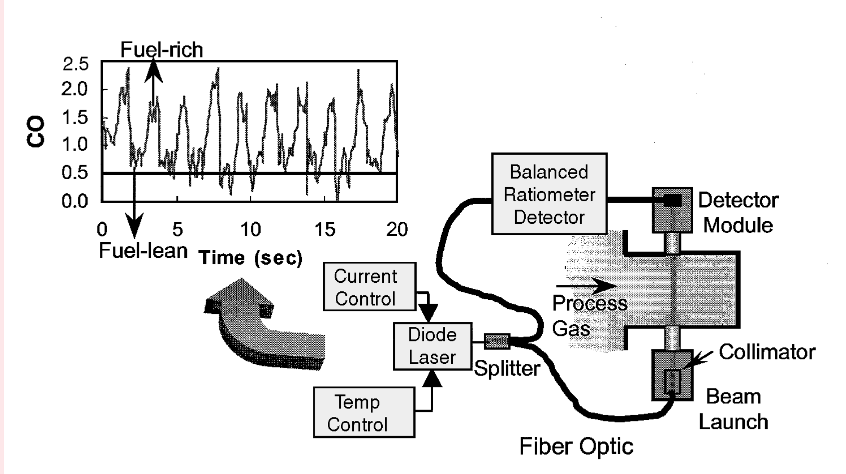
This sensor system targets improved energy use and reduced emissions for industrial furnaces. Potential applications include optimized oxygen injection for electric arc furnace steel production and in reheat furnaces in steel production. Improved energy use for glass melting requires continuous monitoring of gas composition and temperature within the furnace, and the NO_x emission from such furnaces is extremely sensitive to the presence of excess oxygen. NO_x emission can be minimized with feedback control from a continuous, *in situ* monitor. Thus, many potential applications exist for *in situ* monitoring in chemical processing industries.

Tunable diode laser sensors will provide simultaneous monitoring of combustion gases and temperature for control of industrial furnaces

A sensor system based on the use of tunable diode lasers will allow for *in situ* determinations of the concentrations of carbon monoxide, oxygen, and water vapor as well as measurement of gas temperature in industrial furnaces. Advanced telecommunication fiber optical components and rapidly tunable lasers will be able to determine the concentrations of multiple species and the gas temperature using only two diode lasers. Individual measurement times are expected to be approximately 10 to 15 milliseconds with time-averaged measurements requiring about one-tenth of a second.

The slow response time of conventional analysis techniques applied to combustion processes cannot capture dynamic variations in the combustion space. The diode laser sensor will be able to track gas concentrations of target species and temperature in a near simultaneous manner. Most existing instrumentation techniques require extractive probes to sample the combustion gases. However, the *in situ* nature of the sensor to be developed in this project will make it the first sensor capable of responding to the actual furnace dynamics as required for advanced combustion control techniques. In addition, the sensor should cost no more than the current, slower sensors.

Tunable Diode Laser Sensor



The diode laser set-up shown above has been used to demonstrate the response time from a dynamic combustion process. The data obtained capture the CO variation in real time.

Project Description

Goal: Develop and demonstrate a tunable diode laser sensor for emissions control and improved energy use in various industrial combustion processes.

The sensor will use a 763-nm diode laser for oxygen measurements and, for carbon monoxide and water vapor, a newly available diode laser capable of tuning over a range of 50 nm around 1.55 micrometers at microsecond rates. The near-infrared light from the lasers is directed through fiber optics to a collimator mount and then through a combustor duct with a photodiode detector mounted on the other side of the duct. The composition of the gas can be determined by measuring the transmittance of the light through the sample along with certain parameters that can be obtained prior to the measurement. The temperature measurements are based on using the relative intensity of two transitions of the same molecule that originate in different lower states.

The most significant challenges to the sensor are the presence of particulates in the optical field of view and the effect of furnace radiation on the noise level of the detector. A beam expander will be used to reduce the noise impact of the particulate loading. If the background radiation that falls on the detector is too intense, it can drive the photodetector into saturation so that the intensity of the laser signal cannot be measured. Fluctuations in the background radiation due to glowing particulates or reflected flame flicker can also limit sensor accuracy. These issues will be addressed by designing improved optical launch and collection systems that restrict the optical field of view and spectral bandwidth.

Progress and Milestones

- This project was selected through the Sensors and Controls Program FY00 solicitation and was awarded in January 2000. All tasks are scheduled for completion in 36 months.
- Phase I of the project will consist of four tasks to be completed by the end of the first year of the project:
  a) The first two tasks will be to install a laser upgrade in the prototype sensor and to validate the accuracy of the technique used for temperature measurements.
  b) The next step will be to validate the multispecies measurement approach using a laboratory burner.
  c) Phase I will be concluded with pilot-scale testing on Air Liquide's pilot furnace.
- The continuation of the project into Phase II will be dependent upon successful completion of the Phase I pilot-scale tests described above.
  a) The first task of Phase II will be to complete the detailed design of an industrial prototype sensor. This sensor will include robust and hardened optical integration components to replace the laboratory versions used for the pilot-scale tests.
  b) Pilot-scale testing of the industrial sensor, industrial sensor rework and modifications, and industrial site test planning and preparation will be completed by the end of the second year of the project.
  c) Industrial site testing will occur during the third year of the project. Facilities operated by Dupont, Johns-Manville, and Charter Steel will be used for these tests.
  d) After evaluation of the industrial site testing, one site will be selected for a long-term (minimum of four weeks) demonstration in which the sensor will be integrated into a control scheme to provide feedback control on the fuel and oxide.

Project Partners

American Air Liquide, Inc.
Chicago Research Center
Countryside, IL

Physical Sciences, Inc.
Andover, MA

For Additional Information, Please Contact:

Eric Lightner
Office of Industrial Technologies
Phone: (202) 586-8130
Fax: (202) 586-1658
Eric.Lightner@ee.doe.gov
www.oit.doe.gov/crosscut/sens_cont

Please send any comments, questions, or suggestions to webmaster.oit@ee.doe.gov.

Visit our website at www.oit.doe.gov.

Office of Industrial Technologies
Energy Efficiency
and Renewable Energy
U.S. Department of Energy
Washington, D.C. 20585

May 2000